Report of the Sub-Commission for North America
IAG Commission X (Global and Regional Geodetic Networks)
1999 to 2003

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Operating on a informal basis since 1997, the Sub-Commission for North America was formally created in 1999, immediately following the IUGG General Meeting in Birmingham, U.K. The purpose of the Sub-Commission is to provide international focus and cooperation for issues involving the horizontal, vertical, and three-dimensional geodetic control networks of North America, including Central America, the Caribbean and Greenland (Denmark). Some of these issues include:

- Densification of the ITRF reference frame network in North America (the North American Reference Frame) and promotion of its use.
- Maintenance and future evolution of vertical datums (ellipsoidal and orthometric), including NAVD88 and the International Great Lakes Datum.
- Collocation of different measurement techniques such as VLBI, SLR, DORIS, GPS, etc.
- Effects of crustal motion, including tectonic motions along, e.g., the western coast of N.A. and in the Caribbean, and post-glacial rebound.
- Standards for the accuracy of geodetic positions.
- Outreach to the general public through focused symposia, articles, workshops and lectures and technology transfer to other groups, particularly in N.A.

The membership of the Sub-Commission presently consists of:

Michael. Craymer (NRCan/GSD, Canada, co-President)
Dennis Milbert (NOAA/NGS, U.S., co-President)
Per Knudsen (KMS, Denmark)

No members have yet been identified for Mexico and the Caribbean, although contacts have been made with Mexico and the appointment of a representative is expected soon.

The members of the Sub-Commission are largely responsible for identifying the issues to be addressed and for forming working groups (WGs) to actively resolve these issues. The follow working groups have already been created:

North American Reference Frame (NAREF)
Reference Frame Transformations
International Great Lakes Datum (IGLD)

Most recently, a new Stable North American Reference Frame (SNARF) Working Group is being formed in collaboration with UNAVCO Inc. to develop a highly accurate, stable North American Reference Frame fixed to the North American tectonic plate. Such a reference frame is required for the high accuracy studies of intraplate crustal motion being contemplated by, e.g., the Earthscope project (http://www.earthscope.org/).

Activities within each of these working group are discussed below.

North American Reference Frame (NAREF) Working Group

This is the most active working group of the Sub-Commission. The primary purpose of the WG is to densify the ITRF reference frame in the North American region by organizing the computation and combination of weekly coordinate solutions and associated accuracy information for continuously operating GPS stations that are not part of the IGS global network. Cumulative solutions for coordinates and velocities will also be determined on a regular basis once a sufficiently long series of weekly solutions is obtained. The WG organizes, collects, analyzes and combines solutions from individual agencies, and archives the results. These results are available on the NAREF web site and, since mid-2002, weekly combinations are also being submitted to the IGS Global Data Centers.

The goals of the WG and some of it's work have been promoted at various conferences over the past year and a half, beginning with the special session "Densification of the ITRF in North America" at the American Geophysical 2000 Spring Meeting (Craymer and Milbert, 2000; Craymer et al., 2000). More recent results from this work group are available at www.naref.org.

The current contributing members of the WG are:

Michael Craymer (NRCan/GSD, Canada – Chairman)
Bill Dillinger (National Geodetic Survey, USA)
Mike Cline (National Geodetic Survey, USA)
Mieczyslaw Piraszewski (NRCan/GSD, Canada)
Caroline Huot (NRCan/GSD, Canada)
Brian Donahue (NRCan/GSD, Canada)
Herb Dragert (NRCan/GSC/PGC, Canada)

Scripps Institution of Oceanography (USA)
Finn Bo Madsen (KMS, Denmark)
Remi Ferland (NRCan/GSD, Canada – IGS representative)

These members have been active in providing regional solutions and assistance in combining them. A plot of the current network is given in Figure 1. The addition of the US CORS network solutions by NGS has significantly filled out the coverage and made the densification network truly North American in scope. No success has been made thus far in soliciting weekly solutions for permanent stations in Mexico, although attempts will be made to contact some researchers in US that are computing solutions in this region for their own purposes.

Reference Frame Transformations Working Group

The purpose of this WG is to determine consistent relationships between international, regional and national reference frames/datums in North American, and to maintain (update) these relationships as needed. The WG has been very active on an informal basis since 1997 and includes the following memebers:

Michael Craymer (NRCan/GSD, Canada – Chairman)
Richard Snay (NOAA/NGS, U.S.)
Tomas Soler (NOAA/NGS, U.S.)
Remi Ferland (NRCan/GSD, Canada – IGS representative)

The primary focus of the WG has been on maintaining the relation between the North American Datum of 1983 (NAD83) and the International Terrestrial Reference Frame (ITRF). In fact, NAD83 has now been defined in terms of a 7 parameter Helmert transformation from ITRF96 (Craymer et al., 2000). Transformations to/from other ITRF realizations are determined by adding the incremental transformations between ITRFs, as adopted the IERS and/or the IGS.

This work has unified the fundamental definition of NAD83 in both the U.S. and Canada. Software tools have also been provide for users in both countries to make access to the NAD83 and ITRF reference frames easier than ever.

The North American Datum of 1983 (NAD 83) is currently defined in terms of a 14-parameter Helmert transformation from ITRF00 (Soler and Snay, 2003) in such a way that stations located within the non-deforming part of the North American plate will have little or no horizontal motion relative to this plate. This transformation, denoted (ITRF00 --> NAD 83), equals the composition of three separate transformations

(ITRF00 --> ITRF97) + (ITRF97 --> ITRF96) + (ITRF96 --> NAD 83)

where (ITRF00 --> ITRF97) represents the Helmert transformation from ITRF00 to ITRF97 adopted by the International Earth Rotation Service, (ITRF97 --> ITRF96) represents the Helmert transformation from ITRF97 to ITRF96 adopted by the International GPS Service, and

(ITRF96 --> NAD 83) represents the Helmert transformation from ITRF96 to NAD 83 adopted by Canada and the United States (Craymer et al., 2000).

International Great Lakes Datum (IGLD) Working Group

The purpose of this working group is to consider problems related to the maintenance of the vertical datum for the management of the Great Lakes water system, including post-glacial rebound, the use of GPS/geoid techniques, lake level transfers through hydrodynamic models, comparisons with NAVD88 and the possible implementation of a revised height system.

The Coordinating Committee on Great Lakes Basic Hydraulic and Hydrologic Data recently released their report, "Apparent Vertical Movement Over the Great Lakes - Revisited," in which they documented apparent vertical motion as derived from decades of water-level data, in combination with deglaciation models (see, e.g., Mainville and Craymer, 2003). Further cooperation with this Subcommission (especially, the NAREF WG) in the area of GPS monitoring of crustal motion is expected as more GPS data is gathered for the accurate and reliable estimate of crustal movements over the region.

Other Activities

In addition to the formal activities of the Subcommission's working groups, all countries of the Subcommission have been very active in the past couple of years maintaining and enhancing their own geodetic networks.

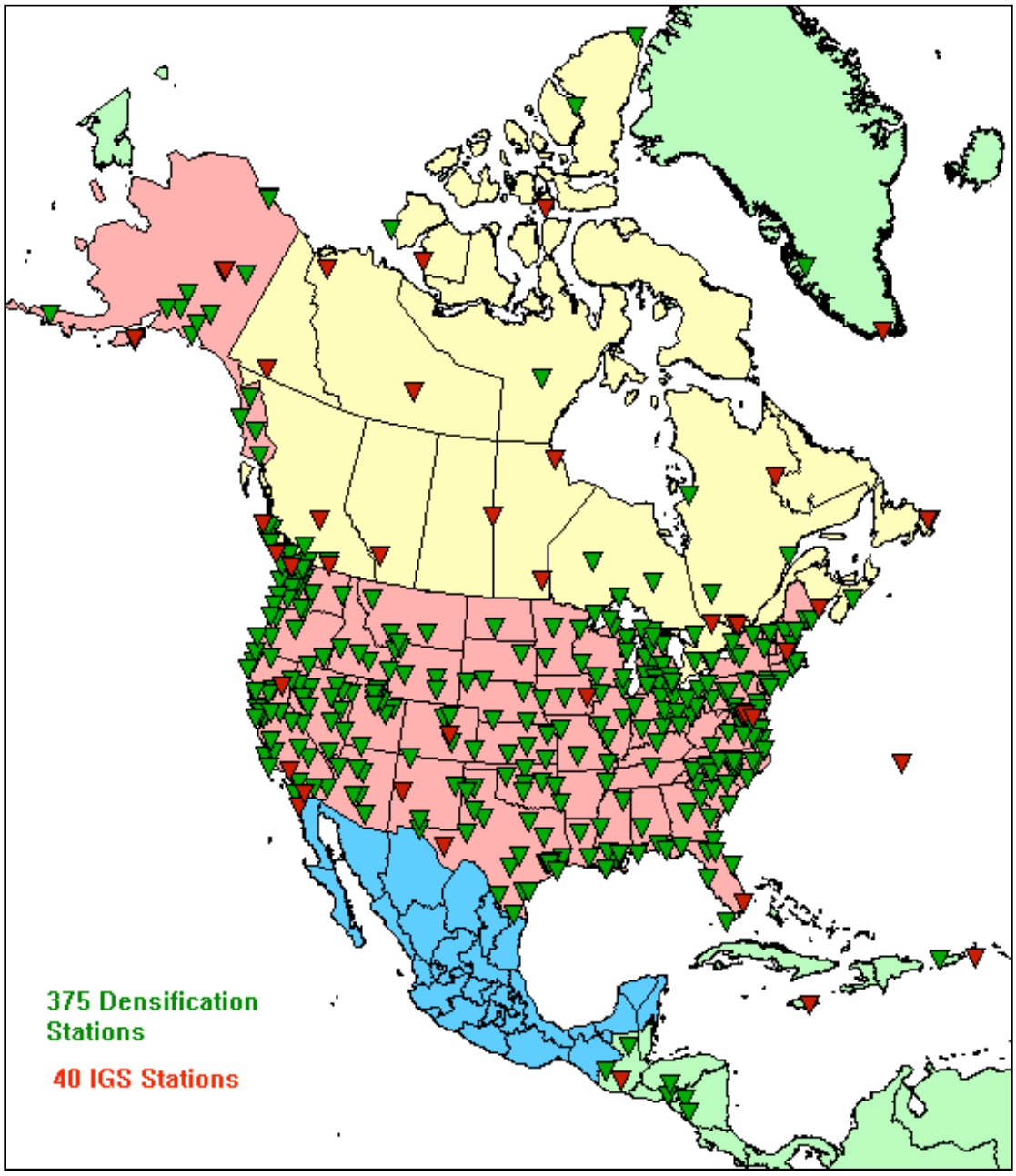

Figure 1: Current NAREF densification network. Red symbols represent IGS global solutions and green symbols the NAREF densification stations. Note that three regional densification stations in the Arctic have now become global stations.

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CORS Newtorks

More than 80 organizations in the United States have collaborated to establish the U.S. National and Cooperative Continuously Operating Reference Station (CORS) networks. Stations typically are part of the National CORS network, the Cooperative CORS network, or both. The National CORS network is comprised of stations whose GPS data are archived at the U.S. National Geodetic Survey. The Cooperative CORS network is comprised of stations whose GPS data are available directly from the organization that operates the station. A station whose GPS data are distributed both by NGS and by a cooperating organization is designated as a Combo CORS. Data and information about CORS can be obtained at:

http://www.ngs.noaa.gov/CORS/

The National CORS currently (March 2003) contains more than 360 sites and the Cooperative CORS has over 43 sites. Most notable among the partners is the California Spatial Reference Center (CSRC) which provides data from more than 250 CORS in California; bringing the total number of CORS to well over 600 stations. Other organizations that distribute GPS data for Combo CORS include the International GPS Service (IGS), the Pacific Northwest Geodetic Array (PANGA), and state agencies in Florida, Ohio, Michigan, North Carolina, Pennsylvania, South Carolina, Texas, and Vermont. A listing with web links to organizations and their GPS CORS networks is maintained at:

http://www.ngs.noaa.gov/CORS/links1/

The CORS network also contains stations in several U.S. territories, in Central America, and in the Caribbean. With this coverage, more than 96 percent of the coterminous United States is located within 200 km of a CORS, and more than 60 percent within 100 km. And, the CORS network is currently growing at a rate of about 6 stations per month.

In addition to data archival and dissemination, National CORS operations include daily coordinate solutions to quality control the GPS receiver data. Stations in the CORS network are operated for a variety of applications, including high accuracy positioning, navigation, remote sensing, GIS development, geophysics, atmospheric science, satellite tracking, and timing. The geophysics community is planning to install several hundred additional stations in the United States during the next few years to monitor the crustal motion associated with plate boundary

interactions. Also, organizations in Canada and the United States are collaborating to establish about 20 stations at selected water-level sites located on the Great Lakes.

ITRF00 Positions and Velocities

The U.S. National Geodetic Survey (NGS) delivered two separate GPS contributions towards the realization of ITRF00 in year 2000 (Marshall, 2000). NGS has adopted ITRF00-compatible positions and velocities for all stations in the CORS network. Approximately every year, NGS validates adopted ITRF positions and velocities for all CORS. In particular, NGS uses every third day of CORS data in its archives to compute provisional positions and velocities for all CORS relative to the then current ITRF realization, call it ITRFxx. If for any station, these provisional ITRFxx positional coordinates differ from the currently adopted ITRFxx positional coordinates by more than 1 cm in the north-south dimension or by more than 1 cm in the east-west dimension or by more than 2 cm in the vertical dimension, then NGS adopts the provisional position and velocity to supercede the previously adopted ITRFxx position and velocity.

North American Datum of 1983

In March, 2002, NGS upgraded NAD 83 positions and velocities for all CORS sites, except those located on Pacific islands, so that they equal the transformed values of recently computed ITRF00 positions and velocities. This upgrade removed inconsistencies among previously published NAD 83 positions and velocities which are detectable with modern high accuracy GPS surveys. In addition, the NAD 83 coordinates are referred to an epoch date of 2002.00. (Previously, NAD 83 positions for the CORS sites were published for an epoch date of 1997.00). The use of the more current epoch date reduces those systematic errors occurring when points are positioned relative to CORS sites without applying appropriate site velocities. This more current epoch date benefits those involved in positioning activities in areas of crustal motion, like western CONUS and Alaska.

In October, 2002, NGS updated NAD 83 positions and velocities for all CORS located on Pacific islands to epoch 2002.0. Stations on the Hawaiian Islands, the Marshall Islands, and American Samoa now refer to the spatial reference frame called NAD 83 (PACP00). Stations on the Mariana Islands (GUAM and CNMI) now refer to the spatial reference frame called NAD 83 (MARP00). The "datum tags", PACP00 and MARP00, indicate that adopted positions and velocities were transformed from ITRF00 positions and velocities, respectively. Stations located in the interior of the Pacific tectonic plate are to have little or no horizontal velocity relative to NAD 83 (PACP00). Stations located in the interior of the Mariana tectonic plate are to have little or no horizontal velocity relative to NAD 83 (MARP00). Note that points located on Pacific islands have velocities in excess of 50 mm/yr relative to the standard NAD 83 reference frame.

OPUS

In 2001, NGS introduced a Web-based utility, called the Online Positioning User Service (OPUS), which will quickly and automatically calculate an accurate 3D position for a location corresponding to a user-supplied file of appropriate GPS data. In particular, this file must

contain dual-frequency carrier phase observations at a single location. OPUS then automatically retrieves GPS data for three suitable CORS for use in calculating the positional coordinates associated with the user-supplied data. OPUS then emails the calculated coordinates to a user-specified email address. The computed coordinates are provided in each of two different reference frames: NAD 83 and the pertinent ITRF realization. For details see:

http://www.ngs.noaa.gov/OPUS/

Network Re-Observation and Readjustment

Over the past several years the National Geodetic Survey has been re-observing the Federal Base Network (FBN) and Cooperative Base Network (CBN) to complete the ellipsoidal and orthometric height components of the FBN and CBN; see

http://www.ngs.noaa.gov/PROJECTS/FBN/

Project requirements for the FBN and CBN observations are to ensure 2-centimeter local accuracy in the horizontal component, as well as 2-centimeter local accuracy for the ellipsoid heights. By the end of 2003 the observations in the 48 contiguous states and the District of Columbia should be complete. Currently, observations for 44 states and the District of Columbia have been completed. Of these, the vector reductions and adjustments have been completed for 39 states and the District of Columbia. By the end of 2004 the vector reductions and adjustments for all 48 contiguous states should be complete. At this time, a comprehensive readjustment of NAD 83 will be completed in cooperation with the Geodetic Survey Division of Canada. Areas outside the contiguous United States (e.g., Alaska, American Samoa, Guam, Hawaii, Puerto Rico, Virgin Islands, etc,) will be included as resources permit their re-observations.

Comprehensive Everglades Restoration Plan

The Comprehensive Everglades Restoration Plan (CERP) is a major project to achieve ecological restoration of the Florida Everglades. The strategy is to restore the ecology by restoring the hydrologic characteristics of the historic Everglades. Hence, extremely accurate heights were needed to control water flow over long distances. Beginning in 2001, NGS has been assisting the U. S. Army Corps of Engineers in a comprehensive effort to establish both leveling and GPS control for the CERP. The leveling portion consisted of over 1500 km of new, First-Order, Class II leveling covering over 1100 bench marks in the region. The GPS portion, completed in July 2002, consisted of a primary (1:1,000,000) network of 64 stations and a secondary (1:100,000) network of 1051 stations. Most of the stations occupied by GPS were also bench marks from the leveling portion. The final product is a combined GPS and optically-leveled network having ellipsoid heights with a nominal 2 cm (95%) network relative accuracy and a similar orthometric height network relative accuracy in a region of about 175 km by 175 km. For general information on the CERP:

http://www.evergladesplan.org/

Magnitude 7.9 Denali, Alaska Earthquake

A magnitude 7.9 earthquake occurred near Denali National Park, AK on November 3, 2002. The geographic coordinates of the epicenter are 63.520N and 147.530W and its depth is 5.0 km. The CORS Data Analysis Team has determined 3-dimensional displacements associated with this earthquake at several CORS located in Alaska. For details, see:

http://www.ngs.noaa.gov/CORS/denali.html

Horizontal Time Dependent Positioning

NGS recently released version 2.7 of the HTDP (Horizontal Time-Dependent Positioning) software (Snay, 1999) for transforming positional coordinates and/or positioning observations across time and between spatial reference frames. Users may also apply HTDP to predict the velocities and displacements associated with crustal motion in any of several popular reference frames.

Version 2.7 expands the list of permissible reference frames to include the new realization of the World Geodetic System of 1984, called WGS 84(G1150), as well as two new reference frames related to the North American Datum of 1983; one called NAD 83(PACP00) in which most points located on the Pacific tectonic plate (Hawaiian Islands, Marshall Islands, American Samoa, etc.) experience little or no horizontal velocity, the other called NAD 83(MARP00) in which most points located on the Mariana tectonic plate (Guam, Saipan, etc.) experience little or no horizontal velocity.

Version 2.7 incorporates a more accurate model than previous HTDP versions for the 3D displacements associated with the magnitude 7.1 Hector Mine, CA earthquake of October 16, 1999.

Users may execute HTDP_2.7 interactively at:

http://www.ngs.noaa.gov/TOOLS/Htdp/Htdp.html

One may also download the HTDP software and related information from this web site.

CORS Supports Crustal Motion Study

Gan and Prescott (2001) analyzed GPS data observed between 1996 and 2000 for 62 CORS distributed throughout the central and eastern United States. Their results suggest that no significant horizontal crustal motion occurs in this part of the country, except possibly in the region encompassing that part of the Mississippi River which is located south of Illinois. Here, points appear to be moving southward relative to the rest of the continent at an average rate of 1.7 mm/yr, with a standard deviation of 0.9 mm/yr. While this rate is not statistically significant, the fact that the motion occurs near New Madrid, MO--where earthquake risk is considered to be high--argues that the motion may be real.

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Recent Highlights

Geodetic Survey Division (GSD) completed another year highlighted by continued improvements to the Canadian Spatial Reference System, strengthened collaboration in global geodetic services and leadership/support for national geodetic initiatives.

GSD continues to be present, active, and well recognised in national and international arenas. At the national level, GSD relies on it's partnership with the provincial geodetic agencies and territories through the Canadian Geodetic Reference System Committee (CGRSC) to deliver, maintain and enhance the Canadian Spatial Reference System (CSRS), including the Canada-wide Differential GPS (CDGPS) initiative, which is a primary project of the CGRSC. GSD's continued involvement in the GEOIDE National Centres of Excellence program has maintained the collaboration across Canada between the various universities, government departments and private companies. Scientific collaboration with Canadian Hydrographic Service (CHS) of DFO, and Geological Surveys of Canada (GSC) also continue.

At the international level, GSD plays a defining role in international standards and the shape of the future of all geodetic activities. This is achieved through direct product contributions, and chairing of International Association of Geodesy (IAG) committees, working groups, special study groups, workshops, commissions, sub-commissions and others. Canadian representation to the UN Action team on GNSS reporting to the UN Committee on Peaceful Uses of Outer Space (COPUOS) is through GSD. Other examples of international collaboration include work with GeoForschungsZentrum (GFZ) of the Republic of Germany on Sea Level change, and with the Ohio State University (OSU), National Geodetic Survey (NGS) and Forecast Systems Laboratory for water level studies in the Great Lakes region.

The Division is recognized as a leader and significant contributor to the International GPS Service (IGS), the International VLBI Service (IVS), the International Earth Rotation and Reference System Service (IERS), the International Gravity and Geoid Commission (IGGC), and the Global Geodynamics Project (GGP) among others. GSD continues to be actively involved in the IAG Subcommision 10 for North America which is concentrating on developing an integrated North American Reference Frame (NAREF) solution, and a member of a federal government working group overseeing Canada's involvement in the European Union's GALILEO program and continues to monitor progress of this initiative.

Activities continue to be consistent with the long-term strategic focus toward space-based positioning. The following are highlights of this effort that relate to the activities of IAG Commission X.

International GPS Service (IGS)

GSD continues to collaborate and exchange GPS data and products from its network of Active Control Points through its many roles within the IGS, which include Analysis Centre, Coordination for the IGS Reference Frame, and co-chair of the Real-Time Working Group, among others. Norman Beck is also an elected member of the IGS Governing Board.

Global Reference Frame

Regular Very Long Baseline Interferometry (VLBI) operations continue at fiducial stations Algonquin Park Radio Observatory (ARO) and Yellowknife (YELL) as part of GSD's contribution to the International VLBI Service (IVS), in order to relate the national and global terrestrial reference frames to the fixed Celestial reference frame. ARO has maintained it's designation as a primary site of the International Space Geodetic Networks of the Committee for Space Techniques in Geodesy because of it's long history of stability, continuous operation and the multiple geodetic techniques employed, which provides scale and long term control for other techniques including GPS.

International VLBI Service (IVS)

Dr. Bill Petrachenko was recently elected to the IVS Governing Board.

Global Integration

Norman Beck has taken part in a working group tasked with implementing the charter project of the IAG called Integrated Global Geodetic Observing System, that is expected to formally kick off during IUGG this July. Remi Ferland and Jan Kouba participated in reviewing and charting the direction of the IERS.

Activities Supporting Geodynamics/Crustal Motion Studies

GSD has been collaborating with several agencies (both internationally, and nationally) on the measurement of crustal motions in various regions of Canada.

Together with the Ohio State University, the U.S. National Geodetic Survey and Forecast Systems Laboratory, GSD has contributed to the establishment of the Great Lakes Continuously Operating Reference Stations Network with the aim of enhancing national vertical datum monitoring, safe navigation, weather forecasting, precision farming, geodynamics, shoreline environmental monitoring and recreational boating and tourism. For it's part, GSD has established 5 regional GPS active control points at Kingston, Port Weller, Parry Sound, Rossport and Hearst. All but the latter are co-located at CHS water level gauges.

Collaboration continues with Geological Surveys of Canada on the project "Relative Sea-level and Associated Climate Impacts on Northern Coasts and Seaways". With the goal of determining relative vertical crustal motion in the western Arctic, GSD has established and operates 3 regional active control points at Inuvik, Resolute and Sachs Harbour, as well as periodically re-occupying several non-permanent stations in the region.

As part of another collaborative project with GSC to conduct crustal deformation measurements across Vancouver Island under the "Natural Hazards" envelope, GSD managed a special order levelling contract along a profile across Vancouver Island.

Other field measurements conducted this past year for GSC included absolute gravity, and GPS at collocated sites. Through the use of these independent observational techniques, a more accurate estimate of present-day uplift rates across the coastal margin will be determined.

GSD has also been collaborating with Fisheries and Oceans Canada (DFO) on the establishment of permanent GPS stations at newly established tide gauges in the Arctic as part of Canada's contribution to the international Global Ocean Observing System (GOOS), an initiative to establish an global array of tide gauges about 1000 km apart along the world's coastlines to determine long-term changes in sea level due to climate change. GPS active control points have been co-located with tide gauges at Alert, Holman and Nain. Two more will be established in 2003 at Qikiqtarjuaq (Baffin Island) and Tuktoyuktuk. These GPS stations are also being contributed to the IGS GPS Tide Gauge Benchmark Monitoring (TIGA) Pilot Project, another effort to establish a global network of tide gauges co-located with permanent GPS stations.

Through a tri-lateral (GSD, GFZ of Germany, and GSC Pacific) MOU for cost-shared development of an infrastructure aimed at monitoring the vertical movement of the Earth's crust in the broad region around Hudson Bay, six new regional GPS active control points have been established and integrated to the Active Control System network. Results of a N-S absolute gravity survey east of James Bay were presented at the Fall AGU. The presentation showed the correspondence of GPS-measured uplift rates with those of GSD's JILA-2 absolute gravimeter at selected sites.

Canada-Wide DGPS (CDGPS) Service

CDGPS is the CCOG sponsored initiative to broadcast GSD's GPSoC as a means to enable GPS positioning through coordinates consistent with the Canadian Spatial Reference System. Service Launch is scheduled for the 2003 field season. NRCan has provided extensive engineering support to the CDGPS project to ensure the success of the project, especially as Beta Trials approach. This work included the implementation of a fully managed infrastructure for provision of GPSoC corrections to CDGPS since November 2002, GTIS liaison for issues related to MSAT power and bandwidth, systems management, and the implementation of a verification and validation system at MSV. A revised Service Agreement between NRCan and GTIS reflecting the MSAT arrangement has been prepared.

Canadian Active Control Infrastructure

Over the past year, two new ACP sites have been established, at Fredericton, New Brunswick (FRED), and National Research Council in Ottawa, where the original site (NRC2) was decommissioned and a new site (NRC3) established.

GPS-C Testing

Successful testing and operational use of GPSoC was carried out by the Canadian Hydrographic Service (CHS) in the Eastern Arctic and Lake Temiscaming areas during the 2002 field season. CHS has again requested access to GPS∑C for the 2003 season, making this their 6th year using real-time positioning for Arctic operations.

Canadian Base Network

The Canadian Base Network (CBN) was completed in 2000 with the addition of 6 new stations in the Arctic. This completed the Canada-wide network of 154 monuments that provide a more traditional but very high accuracy control network for further densification by individual provinces. Remeasurement of the entire network took place in 2001 and 2002 in order to monitor monument stability and to determine the effects of post-glacial rebound. Remeasurements are expected to occur on a 4-5 year basis or as needed to provide a more accurate determination of post-glacial reboud and thus more accurate, up-to-date coordinates.

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Five geodetic permanent GPS stations are now in operation in Greenland. The Geodetic Department of the National Survey and Cadastre of Denmark operates and maintains the stations at the Thule Airbase (THU1 and the newly established THU2) and in Scoresbysund (SCOB). Stations KELY and KULU in Kelyville and in Kulusuk, respectively, are operated by the University of Colorado. The stations THU1 and KELY are included in the IGS global network. THU2 was established in 1998 as a long-term stable station to complement the THU1 station. THU2 is equipped with a GPS/GLONASS receiver and has contributed to the IGEX and the IGLOS campaigns. Recently, THU2 was accepted for the IGS LEO network. A new station in southern Greenland is being established in Julianehaab to complete the coverage in the region.

Activities associated with the upgrading of the geodetic network in Greenland have been going on for several years. In 1996, the REFGR reference frame for Greenland was defined and includes eight globally positioned reference points. Since then, GPS points have been established throughout the populated parts of Greenland. In 2000, a special effort was made to complete this task. Sixty-seven settlements were visited and 171 new points established. Most new points were established at old reference points so that the classic geodetic triangulation measurements can be used together with the GPS coordinates in the computation of the new coordinates. The software for the combined adjustment of the new and the classic measurements was developed and new coordinates for most of the ice free parts of Greenland have been computed during 2001.

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